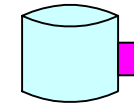


Axiomatic Safety-Critical Assessment Process (ASCAP++) Toolset Overview

Model Library



Standard Classes of Objects and Agents for each Control System Type

Track Objects

- Highway Grade Crossings
- Switch Machines
- Track Circuits
- Active/Passive Beacons
- Etc.

Stationary Objects

- Interlocking Controllers
- Signals
- Wayside Signage
- Landslide Detectors
- Etc.

Mobile Objects

- Train Consists
- Maintenance Vehicles
- Positioning Systems
- Track Circuit Readers
- On-Board Displays
- Etc.

Agents

- Train Dispatcher
- Maintenance of Way Worker
- Train Crew
- Etc.

Model Builder

Select Control System Type

- Direct Traffic Control (DTC)
- Traffic Control System (TCS)
- Centralized Train Control (CTC)
- Positive Train Control (PTC)
- Communication-Based Train Control (CBTC)
- Magnetic Levitation (Maglev)

Track Configuration Population

Define Track Infrastructure Objects, with Associated Geographical Characteristics (Grade, Elevation, Super-elevation, Curvature)

Object Population

Define Stationary Objects

- Central Office Devices
- Wayside Devices

Define Mobile Objects

- Train Consists
- Maintenance Vehicles
- On-Board Devices

Agent Population

Define Human Agents

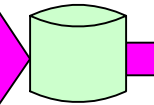
- Train Dispatcher
- Maintenance of Way Worker
- Train Crew
- Train Operator

Create Scheduling and Routing Algorithms

Select Train Line-Specific Severity Database

Specify Simulation Control and Results Output Format Parameters

Model Database



ASCAP++ Internal Format

Application-Independent Mishap Simulation Engine

Initialize N-Train System

- Instantiate Track Infrastructure Objects
- Instantiate Stationary and Mobile Objects
- Instantiate Agents
- Initiate Scheduling and Routing

Global Simulation Control

- Terminate Simulations if Enough Train-Miles have been Accumulated
- Schedule and Inject Periodic Preventative Maintenance

Train N Simulation

Train 1 Simulation

Dynamic Movement Model for Train 1 Identifies Next Train/Object Time and Space Intersection

Solve Object/Agent Probabilistic Models to Find Probability of Being in Each Possible State

Use Monte Carlo Techniques to Select Behavioral State of Each Object/Agent

Blackboard Intersection Outcome Resolution to Determine Train Movement Modality

Event Logging

- Update Object/Agent Behavioral State Counters
- Log any Train Movement Passed at Danger Events

Potential Mishap?

N

Y

Are Other Object/Agent Interactions Triggered by Same Train/Object Intersection?

N

Y

If Required, Continue Using Detailed Train Movement Model

True Mishap?

N

Y

Terminate Simulation and Clean-up

- Create Mishap Log Entry
- Terminate Affected Simulation(s)
- Replace Affected Objects
- Repair Known Failed Objects

Simulation Outputs



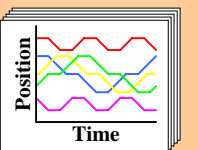
Mishap Logs containing Mishap Intersection plus Last 6 Passed at Danger Events for Affected Train(s)



Object/Agent Behavioral State Statistics

Performance Metric Calculation

- String Charts
- Traffic Throughput
- Traffic Delays
- Hazard-free/Violation-free Operation



System Performance Analysis Module

MTTHE Target Allocation Module

Risk Profile Generation Module

Mishap Log Analysis

Examine Next Mishap

Accident?

N

Y

Determine Societal Cost

Determine Likelihood of Occurrence

Calculate System Risk with Confidence Level

Create Hazard Log Entry

Compare with Supplier's Qualitative Risk Assessments (PHA, FMECA, etc.)

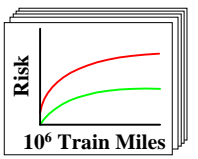
Hazard	Sev/	Freq	Mitigation
Derail due to Ovrspd	II/D	Use of Train Speed Enforcement	

Object Class M Risk Profile Generation

Object Class 1 Risk Profile Generation

Generate Five Risk Containment Regions

- Fault Coverage
- Failure Rate
- Preventative Maintenance
- Corrective Maintenance
- Human Repair Coverage



Project Decision Makers Select Desired Operational Risk Profiles

Processor-Based Sub-System X

Processor-Based Sub-System 1

Determine Relevant Operational Risk Profile(s) for Processor-Based Sub-system 1

Derive Fault Coverage Target from Selected Operational Risk Profile(s)

Axiomatic Safety-Critical Assessment Process (ASCAP++) Toolset Overview